History and Development of the Gas Industry

How Gas—the modern heat—born in an age of superstition, was the first of great discoveries which led the way for the period of greatest progress since the dawn of civilization

Published by
Illinois Committee on Public Utility Information
125 South Clark Street
Chicago

1925

SCHOOLS *may obtain additional copies of this pamphlet* FREE OF CHARGE, *in such quantities as they may deem necessary, by addressing*

ILLINOIS COMMITTEE ON PUBLIC UTILITY INFORMATION

125 South Clark Street

Chicago

FOREWORD

PRIMITIVE man living in caves, tens of thousands of years ago, discovered how to produce fire by rubbing sticks together until friction ignited them. Ever since, down through the ages, fire has played an important part in man's progress. As the use of fire grew, civilization developed.

Making of fire and its uses were crude for thousands of years. The cave man hunting wild beasts for food, roasted his meat on a spit over an open fire.

Progress was slow both in the use of fire for cooking and for illumination. The Egyptians of about 4000 B. C. are known to have made progress in cooking and in the days of Rameses III, about 1600 B. C., food was fried on griddles and boiled in pots. The Assyrians and Babylonians cooked over small braziers and baked in cylindrical shaped stoves. It was the Romans, however, who perfected the brazier and developed cooking into a fine art. Yet, after the fall of the Roman Empire the culinary art of the ancient Romans practically died out and cooking and heating during the Middle Ages relapsed to the crude methods of barbarians.

Pine Knots First Lights

Burning pine knots was probably the first attempt at artificial illumination. It was not until about 1450 B. C. that "fire pans" or "censers" came into use. Oil lamps, which were saucers with wicks dipped into animal oil, were first used about 500 B. C. Later, candles came into general use.

Today gas makes the modern fire. Used first for illumination, it later became employed as a substitute for wood and coal in the kitchen range, and now is making its way into shop and factory, as well as into the home and office. It is receiving constantly increasing attention in this field, as an adjunct of industrial processes, as well as for room and house heating, because it is so clean, adaptable, flexible, easily controlled and efficient and altogether is so easily handled and used without dirt, trouble or waste.

Lighting methods were still primitive until a little more than one hundred years ago. The discovery and utilization of gas marked the most important step in the progress of artificial illumination. Although gas was discovered about the middle of the Seventeenth Century, it was not until in the later years of the Eighteenth Century and the beginning of the Nineteenth Century that man learned how to make it serve a useful purpose.

The introduction of gas lighting marked an important epoch in the progress of civilization. Gas was the first of the number of great

discoveries and developments which made possible, during the last century, greater progress and development in the world than in all the thousands of years of civilization which preceded it.

Gas Companies First Utilities

Companies organized for gas-lighting were the first of what are now commonly known as public utilities. Electric light and power, telephone and electric railway companies followed at later dates. To-day, these public utilities represent an investment in plants and equipment of approximately $18,000,000,000 in the United States alone.

The story of the discovery and development of artificial or manufactured gas, as it is more properly called, is a fascinating romance. Discovered in an age of superstition, its development and use was slow, but once men of vision demonstrated what could be done with it, its development was rapid.

For more than 100 years gas has lighted the way of progress. It was used first for street lighting. Later, public buildings and homes were lighted with gas. In fact, for nearly 75 years, this was practically its only use. Then came electricity. It threatened to take the place of gas lighting. The "Welsbach mantle" which gave six times more light than the open flame burner was perfected in 1896 and gas lighting held its own against electricity for many years. About the same time gas came into quite general use for cooking. Today it cooks the meals for nearly half of the population of the United States, and is used for heating water, for supplementing the home heating plant and for a variety of domestic purposes.

Gas and Electricity Not Competitors

Despite the rapid development of the use of electric light and power, new uses for gas have increased its consumption every year, the consumption today being double what it was ten years ago and more than three and one-half times what it was twenty years ago. Electricity and gas are not competitors in the strict sense of the word, electricity being used chiefly for light and power and gas for heat. There are some instances where they overlap, but broadly speaking each has its own field.

Gas, long the servant of the housewife, is now being utilized by industry on a scale never before thought possible. The industrial use of gas, a development of the last decade, is revolutionizing industry. The next great step in progress will be the heating of cities with gas and coke, the latter a by-product of gas plants. When this is done, smoke will be driven from the cities and the nation's fuel resources conserved.

This booklet traces the history of the development of gas from its discovery down to the present day, gives a glimpse of the future of this great industry and what its further development will mean to America.

I. THE DISCOVERY OF GAS

How the superstitions of the Seventeenth Century postponed its development and use.

MAN'S eternal search for riches and the futile endeavors to change the baser metals into gold, practised for centuries by a class of ancient philosophers, who were known as "alchemists," led strangely to the accidental discovery of artificial gas, now better known as manufactured gas, to distinguish it from natural gas, such as is found in some parts of the world.

Incredible as it appears now in the Twentieth Century, these alchemists of the Fifteenth and Sixteenth centuries, and before, spent their lives searching with the utmost ardor for the secret of unlimited riches and the "philosopher's stone" by means of which, according to the enthusiastic writings of one of these philosophers, "the greatest disease could be cured, sorrow and evil and every hurtful thing avoided, by help of which we pass from darkness to light, from a desert and wilderness to a habitation and home, and from straitness and necessities to a large and ample estate."

Although alchemy was a fruitless effort, it kept alive a spirit of inquiry regarding the metals that led later to a discovery which in a little more than one hundred years has been developed into one of the great industries of the world.

Van Helmont Discovers Gas

It was John Baptist van Helmont of Brussels who saw the futility of his original line of research and made some of the earliest and most important contributions to modern chemistry during the Seventeenth Century. He studied and practiced medicine, and later turned to chemistry and research work. He dedicated himself at first to alchemy and is numbered among the last of that line of philosophers who labored in vain in the eternal hope of making gold. Although a member of a wealthy and ancient family, he preferred his laboratory at Velvorde to all the state and splendor of the court, and eventually abandoned alchemy and turned to a more rational philosophy and research work.

In the course of his experiments with fuels, about 1609, he discovered that they yielded up what he described as "a wild spirit." He found that this "spirit" could be produced in various ways, such as by means of combustion, fermentation and the action of acids on limestone.

In writing of his experiments he said "seventy-two pounds of oak charcoal gave one pound of cinders and the seventy-one pounds remaining served to form the spirit Sylvester." He remarked "there are bodies which contain this spirit, of which they are almost en-

tirely composed, and is therein fixed and solidified, and are made to leave that state by fermentation, as we observe in the fermentation of wine. This spirit, up to the present time unknown, not susceptible of being confined to vessels, nor capable of being produced in a visible body, I call by the name of gas."

Name Delayed Development

So phantom-like and elusive was van Helmont's discovery that he had named it after "geist," the old German word for spirit.

Thus, at its very christening, gas was enshrouded in a veil of mystery that for many generations was to obscure it and carry the suggestion of intangibility to the superficial mind in an age of superstitions.

In fact, it was nearly 200 years after van Helmont's discovery that practical steps were taken to harness this elusive spirit and make it serve a useful purpose.

Although van Helmont recognized the existence of various gases, he perfected no way of confining them and it remained for later adventurers into the realm of chemistry research to perfect methods of storing the gas after it was made, thus opening the way to its ultimate usefulness to mankind.

Discovery of Natural Gas

A few years after van Helmont made his discoveries and while other chemists were endeavoring to become acquainted with the hidden laws of nature, natural gas was discovered in various places in England. These discoveries attracted wide attention.

The earliest description of these finds is in a communication to the Royal Philosophical Society of London in 1667 by Thomas Shirley, in which he mentions that his attention was directed about eight years previously to what was considered to be a spring "where the water did burn like oyle" and "did boyle and heave like water in a pot." On investigation he found this to "arise from a strong breath, as it were, a wind which ignited on the approach of a lighted candle," and "did burn bright and vigorous."

Natural gas was discovered in other parts of the world, and in many places it was believed to be the work of a supernatural agency, and in some instances where the gas became ignited, causing continuous fire, fire-worshipers erected temples.

The early ages were ages of superstition and these ancient people were easily mystified and terrified. In Greece, one summer afternoon several centuries ago, a shepherd was tending his goats. He noticed that some of them wandered about in an unusual manner whenever they came to a certain spot. He walked over to investigate the cause of their peculiar behavior and became affected himself from something

which arose from the ground. He ran to the village and told his neighbors. They hurried back in great excitement and all had the same experience. They became talkative and light-headed. They acted queerly and their conversation became disconnected and difficult to understand. The villagers agreed that they were in the presence of a supernatural agency and decided that a god was living there. Later, they appointed a priestess to communicate with this god and built a temple where persons might go for advice. Thus, the Oracle of Delphi became famous.

Gas and The Oracle of Delphi

The gas at Delphi is thought to have been natural gas. This gas was found in many parts of the world, but it was many centuries before its value was understood and it was used. In some countries it was utilized to some extent during periods of more advanced civilization, but in other countries, where development of the people was not so far advanced, it mystified and frightened.

Long before artificial gas was discovered by van Helmont and the natural gas wells began to attract attention in Europe, the Chinese are said to have utilized natural gas. Discovering it during that period of Chinese development, which later deteriorated, the Chinese piped the gas through tubes of bamboo and used it for lighting, but it never became of popular or general use.

Dr. John Clayton, a Yorkshire minister with a predilection for the sciences, robbed the spirit of some of its elusive qualities and brought it within the realm of practical things by experiments conducted from 1660 to 1670. He found at Wigan what he described as a "shelly coal." Heating this coal in a closed vessel he found that a "spirit which issued out caught fire at the flame of a candle." Dr. Clayton delighted in amusing his friends with demonstrations of the use of this gas. He would collect the gas in bladders and by pricking holes in them with a pin would light the colorless gas with a candle.

Superstitions Blocked Progress

But, although Dr. Clayton succeeded in producing van Helmont's "wild spirit" from coal, he, like many other research workers, failed to turn gas to practical use.

Progress in the development of gas was slow; because of the superstitions which surrounded it. Civilization had passed through the sperm oil age of lighting to the age of the wax and tallow candle, which was still the common method of illumination late in the eighteenth century, when William Murdock devoted himself to the task of producing gas from coal on a scale that would make possible its use for lighting. By distilling coal in an iron retort and conducting the gas through 70 feet of tinned and copper tubes, Murdock, in 1792, succeeded in lighting his home at Redruth in Cornwall.

Murdock was a construction and erection engineer for James Watt, developer of the steam engine. In 1798 he had progressed so far that he moved from Cornwall to the works of Boulton, Watt & Company, manufacturers of steam engines at the Soho foundry, where he built an apparatus on a large scale and lighted the factory with gas.

First Successful Gas Lighting

On the occasion of the celebration of the Peace of Amiens—the signing of a treaty between Great Britain with France, Spain and Holland—in April, 1802, a public display of the new light was made which attracted wide attention and comment.

Matthews, one of the earliest writers on gas lighting, in describing this spectacle, says:

"The illumination of Soho works on this occasion was one of extraordinary splendor. The whole front of that extensive range of buildings were ornamented with a great variety of devices that admirably displayed many of the varied forms of which gas light is susceptible. This luminous spectacle was as novel as it was astonishing and Birmingham poured forth in numerous population to gaze at and to admire this wonderful display of the combined effects of science and art. The writer was one of those who had the gratification of witnessing this first splendid public exhibition of gas illumination and retains a vivid recollection of the admiration it produced."

Murdock built a gas works and lighted the cotton mill of Messrs. Phillips & Lee at Manchester with 900 burners in 1804. He read a paper describing this installation before the Royal Society of London on February 25, 1808, and was awarded the Count Rumford Gold Medal.

Murdock Versatile Inventor

Murdock was regarded as a queer young man. He was addicted to wearing wooden hats, and, also, made a lantern by fixing a tube in the neck of a gas-filled bladder. The sight of him wandering about the streets at night with this strange beacon filled the neighborhood with dismay, and some of the good people suspected him of being in league with Lucifer and consequently a person to be avoided.

Despite his eccentricities, however, Murdock was a hard worker and a versatile inventor. He made many important improvements in steam engines, in addition to his development in the use of gas. He introduced the "D" slide valve, which is used in gas meters as well as in steam engines. Previous to the time he lighted his home with gas, he is said to have received a salary of twenty shillings a week. Having established his reputation as a "practical" inventor, his salary was increased to twenty pounds a week. This seems to have been about the extent of his profit from his inventions.

On one occasion, it is related, Murdock desired to stop the flow of gas, which was burning from an open tube, and to accomplish this, he picked up a thimble and clapped it over the flaming end of the tube. The thimble had been pierced in many places and the gas coming through the holes in smaller volume was brought into contact with a greater proportion of air at the point of combustion. The result was a much better light. This incident was the origin of the "gas tip" which later came into general use.

Early Gas Equipment Inventions

While Murdock was conducting his experiments and demonstrations, others were also actively engaged in the effort to harness "the spirit of coal." Murdock's achievements, however, were along such practical lines that he is recognized as the father of the gas industry.

Jean Pierre Minckelers, after many experiments in 1784, lighted gas distilled from coal as a demonstration to his class in the University of Louvain, and three years previously Lavosier invented a gas holder which was used instead of bladders, the common receptacles for storing gas among the early adventurers in gas manufacture.

In France, however, Philippe Lebon was the most active and successful. He obtained a patent for making gas by distilling coal or wood in September, 1799, and lighted his home and gardens in the Rue St. Dominic, Paris, in 1801.

The art of gas manufacture took definite form after Murdock had blazed the way. The demonstrations of both Murdock and Lebon attracted wide attention and praise by the press and thus came incidentally to the attention of Frederick Albert Winsor, a German, who was destined to play a most prominent part in establishing the first gas company in the world and probably accelerating the general use of gas for domestic purposes.

Winsor's Discoveries Important

Winsor, who seems to have been more of a promoter than a scientific research worker, journeyed from Frankfort to Paris, where he witnessed several times "the wondrous effects of common smoke being made to burn with greater brilliancy and beauty than wax or oil." He endeavored, unsuccessfully, to learn the secret from Lebon.

He possessed perseverance and energy, however, and the following winter exhibited at Brunswick, in the presence of the reigning duke, Charles William Ferdinand, and his court, a series of experiments demonstrating lighting with gas distilled from wood. Winsor later went to London, and there, in 1803, he began experiments and demonstrations which led to practical results.

Whether Winsor conducted his own researches and discovered a process of making gas is not known, but, having been successful in his

experiments, he lost no time in pushing the invention. He delivered many lectures and was the first to advocate the distribution of gas for lighting purposes from central sources. He proposed the organization of a company for "enlightening the inhabitants of London," but he stated his claims so extravagantly that much opposition to his scheme was aroused.

First Patents Obtained

On May 18, 1804, Winsor obtained the first English patent for gas-making purposes. He gave a public exhibition of lighting the Lyceum theatre in London with gas and the London Times, on July 2, 1804, printed the following description of the demonstration:

"Sir Joseph Banks, ever indefatigable in examining and promoting useful discoveries, went last Thursday evening, for the second time, with a large party of his noble and scientific friends to the Lyceum to witness the incredible effects of smoke; the whole theatre was lighted with the same, in a novel and pleasing manner; the arch of lights above the stage had a very striking effect, and from the English grate on the stage (which may be fixed in every room) issued a very brilliant and fanciful light. The products of tar, ammonia and coke were produced and much approved of. Several experiments were made during the course of the lecture, such as boiling a tea kettle and melting ores in a few minutes on a table. It was also proved that a brilliant flame adapted to lighthouses could be formed, which no rain or storm could extinguish. The noble and learned visitors, after a minute examination of the apparatus, stoves and products, expressed the liveliest satisfaction."

Prejudices Delayed Progress

Winsor had a vision of the future of the gas industry, but he was confronted with a Herculean task in fighting against old-established customs and prejudices. All of his predictions regarding the utilization of gas have proved true during the last fifty years. Although for many decades after he established the first gas company, gas was used only for lighting purposes, Winsor, more than one hundred years ago, foresaw some of its present day uses.

"Since the beginning of the world," said Winsor in one of his early appeals, "mankind has lost above eighty per cent in all combustibles by the mere evaporation of smoke. This very smoke, which often proves troublesome and dangerous to health and houses, is now discovered to contain the most valuable substances, and if properly extracted, gathered, washed, purified and resolved, we gain no less than five costly products, viz, oil, pitch, acid, coke and gas; which latter product not only furnishes the most intense heat, and the purest light, whenever it is wanted, but can also be applied to supersede the dangerous and expensive steam-engines, because a celebrated French

engineer proves that the azote it produces, by a mixture with the atmospheric air, is capable of tenfold power if employed at the freezing point only."

Great Savings Were Visualized Early

Winsor claimed that gas could be used for heating as well as lighting and that it would result in a three-fourths saving in the construction of buildings because of the elimination of chimneys, stoves and other equipment used in burning other fuels.

"Nay," he remarked in one of his pamphlets, "it will almost appear incredible to assert, that the same table, desk or sideboard, which furnishes a light or flame, will serve to warm my room, and even dress my victuals in case of need; and, by the mere turning of a cock, or the corking or uncorking of a small pipe or tube."

Winsor was a versatile and persistent advertiser. Not content with exploiting the wonders of gas in prose alone, he sometimes dashed off a "poem."

Here is a sample of his verse:

"Must Britons be condemned for ever to wallow
In filthy soot, noxious smoke, train oil and tallow,
And their poisonous fumes for ever to swallow?
For with sparky soots, snuffs and vapors, men have constant strife;
Those who are not burned to death, are smothered during life."

Poetic Utterances Brought Opposition

The ardent manner in which Winsor pursued his subject and his extravagant claims of the advantages of gas lighting excited great opposition to his scheme and made him the object of ridicule. Sir Walter Scott, who was much opposed to Winsor's scheme, wrote to a friend saying:

"There is a madman proposing to light London with—what do you think? Why, with smoke."

Napoleon, when he heard of the plan to light London's streets with gas, dismissed the idea as "une grande folie." Actors in the music halls poked fun at the tireless inventor and promoter, and a humorous writer burlesqued Winsor and his claims in a poem which ended in this fashion:

"And when, ah, Winsor!—distant be the day—
Life's flame no longer shall ignite thy clay;
Thy phosphor nature, active still and bright,
Above us shall diffuse post-obit light.
Perhaps, translated, to another sphere,
Thy spirit—like thy light—refined and clear—
Ballooned with purest hydrogen, shall rise,
And add a patent planet to the skies.
Then some sage Sidrophel, with Herschel eye,
The bright Winsorium Sidus shall descry;
The Vox Stellarum shall record thy name,
And thine outlive another Winsor's fame."

Despite the opposition and ridicule, Winsor continued his task and succeeded in getting the support of a large and influential body of shareholders in his company, and the first public street lighting with gas took place in Pall Mall in London on January 28, 1807. This demonstration did much to expel many of the doubts existing as to the practicability of his discovery.

First Gas Company In 1812

Winsor sought for his company the exclusive privilege of lighting by gas in all the British possessions, but such a broad charter was refused. In April, 1812, Parliament granted a charter to his company "The London and Westminster Gas Light & Coke Company" and thus the first gas company in the world came into being.

On December 31, 1813, Westminster Bridge was lighted with gas, and the populace of London was dumbfounded by the spectacle. It was many years before the citizens of that city became accustomed to gas lighting, although it was extended rapidly after the lighting of the bridge. People thought the flame came through the pipes and many objections were raised when the system was installed in the House of Commons. So little was known about gas that it was thought that the "pipes would burn the building" and they were set far away from the walls, and the members of Parliament, fearful of being burned, would not touch them with ungloved hands. Lamplighters at first refused, through fear, to light the new gas lamps, and later crowds followed them to watch their operations every evening.

Baltimore First American Gas User

Following the success of gas lighting in London it spread quickly to other countries. In the United States, Baltimore, in 1816, was the first city to light its streets with gas, and, in 1820, Paris was lighted with gas.

Little did van Helmont, working in his laboratory in Brussels, discovering the mysterious spirit which he could not imprison, think that his discovery would be the foundation of an industry which in the United States alone today represents an investment of about $4,500,000,000.

II.—DEVELOPMENT OF THE USE OF GAS

Inauguration of gas lighting in the United States and other parts of the world and how the industry grew.

IT was in Baltimore that gas lighting got its start in the United States. Although there were a few isolated instances of gas being used by individuals in other cities previously, introduction of gas lights in Rembrandt Peale's museum in Baltimore in 1816 proved to be such a sensation and success that it led to the organization of a gas company and the lighting of the streets of that city with gas.

"Gas Lights without Oil, Tallow, Wick or Smoke" in the "Museum and Gallery of the Fine Arts in Holliday Street" was the way Peale made his announcement in newspaper advertisements on June 13, 1816. An admission fee was charged for the privilege of viewing this wonderful light and it proved to be even a greater attraction than the skeleton of a mastodon, which his father, Charles William Peale, a portrait painter, had dug up at Newburg-on-the-Hudson, and which, up to that time, had been the chief feature of the museum. People flocked to see the new lights and the exhibition was so successful that talk of lighting the streets of Baltimore began immediately.

First American Gas Company in 1816

The city council passed an ordinance on June 17, 1816, permitting Peale and others to manufacture gas, lay pipes in the streets and contract with the city for street lighting. Thus the first gas company founded in the United States began to operate in Baltimore in 1816. On February 5, 1817, it was incorporated as the Gas Light Company of Baltimore.

The first recorded demonstration of gas in the United States was in Philadelphia in August, 1796, according to Watson's "Annals of Philadelphia," which relates that the gas was manufactured by M. Ambroise & Company, Italian fireworkers and artists. In Richmond, Virginia, in 1803, a huge gas lamp was erected on a forty foot tower in Main Street, near Eleventh Street, which for a time attracted much attention. This was four years before the first public exhibition of street lighting was given in Pall Mall in London and seven years before the first gas company was organized in that city, but it did not endure as Main Street went back to its animal oil lamps.

First Home Lighted by Gas

A few years later, in 1812, David Melville of Newport, R. I., lighted his home and the street in front of it with gas which he manufactured. Also, he lighted a factory at Pawtucket and induced the government to use gas at Beaver Tail Light House.

Baltimore, however, was the first city to use gas successfully, and other cities followed her lead. Introduction of gas lighting was not rapid, however, because, it being a radical change from the common methods of lighting of those days, it was regarded with fear by many people and as many objections were made against it in the United States, as had been made in London when introduced there.

A proposal to introduce gas lights in Philadelphia met with strong opposition. In 1830, after gas lighting was used in Baltimore, Boston and New York, Philadelphia still fought against it and "A Public Remonstrance Against Lighting with Gas" was drawn up by prominent citizens, who were successful in blocking the innovation in street illumination until 1836 when the city finally consented to the use of gas as a substitute for candles, lanterns and whale oil lamps, which were the common methods of lighting in those days.

Many Objections to Gas Lighting

In New England, the proposal to light the streets of one of the towns with gas aroused a storm of protest. Following are some of the arguments printed in a New England paper, which represented the best and most serious thought of that time:

1. **A theological objection.** Artificial illumination is an attempt to interfere with the divine plan of the world which had pre-ordained that it should be dark during the night time.
2. **A medical objection.** Emanations of illuminating gas are injurious. Lighted streets will incline people to remain late out of doors, thus leading to increase of ailments by colds.
3. **A moral objection.** The fear of darkness will vanish and drunkenness and depravity increase.
4. **Police objection.** Horses will be frightened and thieves embolded.
5. **Objections from the people.** If streets are illuminated every night, such constant illumination will rob festive occasions of their charm.

How Gas Lighting Spread

Gas was used first for street lighting. Later, public buildings were lighted in this way and a few wealthy citizens also lighted their homes with gas. Progress was slow for many years, however, and rates were high, making its use prohibitive to all except the rich. Everybody used candles or sperm oil lamps for home illumination. It was as late as 1865 when the kerosene lamp was put on the market. It met wide favor because of its cheapness and improved light.

It was not until between the years 1865 and 1875 that the use of gas for home lighting began to make any great progress.

Gas was introduced in Chicago in September, 1850, the city at that time having a population of only 23,047. Admiring crowds of

citizens watched the lighting of the gas street lamps nightly. The state legislature, the year previous, had authorized the formation of the Chicago Gas Light & Coke Company. Gas was introduced in Quincy, Rock Island and Springfield, Ill., in 1854, and in Galena, Ottawa and Peoria in 1855. Its use in other cities of Illinois and the country followed rapidly.

Improvements In Light

In 1855, Robert Wilhelm von Bunsen invented the blue flame gas burner, which is still in use today in many places. With this burner it was possible to burn gas economically with an intensely hot, but smokeless, flame. It was such an improvement over the burners previously used that it was instrumental in giving a great impetus to the use of gas.

Gas lighting spread and was the common means of home illumination in the cities of the land when Thomas A. Edison invented the electric light. In September, 1882, the first electric light plant was opened in New York City.

Right at the time when the new electric light threatened to supplant gas, Carl Auer, who studied under Bunsen at Heidelberg, in Germany, made a notable discovery for which he was awarded the title of "von Welsbach" when he gave to the world the incandescent mantle, which is used today generally wherever gas is used for lighting.

Auer discovered, accidentally, that certain rare earths glow brightly when subjected to the flame of a gas burner. He experimented and found that by introducing oxides of cerium and thorium on a cotton webbing, as a "mantle" covering or surrounding the gas flame, these substances could be heated to incandescence without losing form or falling apart and then would produce a much better light than the flat flame or slit-tip burner. Such a mantle produced six times as much light and used less gas than did the flat flame burner. But, like all other improvements in lighting, progress in the use of gas mantles was slow and they were not used to any great extent until 1890. Inverted gas mantles were not introduced until 1900. In 1896 the Welsbach mantle was applied to street lighting with success.

First Uses of Gas for Cooking

At the Centennial Exhibition in Philadelphia, in 1876, a baking powder company demonstrated the baking of cakes on gas stoves, but it was some years before the use of gas for cooking became popular. In fact, it was not until about 1895 that any great effort was made to popularize the use of gas for cooking and heating.

III.—THE FUTURE OF THE GAS INDUSTRY

Development of the industrial use of gas and how gas will drive the smoke from cities and conserve coal resources.

USE of manufactured gas in industry is a comparatively recent development. Although gas had been used for some trade purposes for many years, it has only been within the last ten years, or one might almost say five, that gas has been used extensively for many different industrial purposes.

Manufacturers, especially those in the metallurgical industries, discovered gas to be a highly efficient fuel for heat treating metals. Many other uses have been found for gas in factories, until today it is estimated there are no less than 60,000 different uses of gas in industry.

The growth and extension of the use of gas for industrial purposes came as the natural development in the era of "higher efficiency" in manufacturing plants. The increased cost of labor, the increased cost of solid fuels, such as coal and oil, the frequent railroad car shortages, which resulted in fuel shortages and the increased value of space, resulted in the introduction of gas in thousands of industrial plants throughout the country. In Chicago, alone, today more than 25,000 industries are using gas as a part of their manufacturing processes.

Advantages of Gas In Industry

The use of gas for industrial purposes has many advantages. The fact that it is a clean fuel makes it desirable for use in processes where cleanliness is essential to good products. The absence of smoke and soot in connection with the use of gas also produces better working condition in factories where it is used. It lends itself readily to automatic control.

As gas is available by the turn of a lever, factory owners who have adopted its use have no money invested in a fuel supply; they do not worry about fluctuations in the price of coal or oil, nor about railroad congestions and car shortages.

No space is needed for storing fuel or ashes and there is no cost of ash removal, which is a big item when coal is burned. No insurance is necessary on fuel stock and lower insurance rates on plants are obtained when gas is used.

Gas is being used extensively today for baking bread in big bakeries, making candy, roasting coffee, smoking meat, pasteurizing milk, pressing clothes, melting glass and many different kinds of metal, vulcanizing automobile tires, drying clothes, drying lumber, forging, heating rivets, galvanizing, welding, cutting metal, annealing, hardening and tempering alloy steel, tool dressing, bolt and rivet making, welding locomotive tubes, heating steel structural materials for fab-

rication, flanging and bending pipe, plate heating, soft metal melting, aluminum refining, metal cutting, including plates, steel risers on steel casting and steel scrap, lead refining, silver refining, in treating various metals in ovens and for many other purposes. One Chicago manufacturer uses gas in thirty different processes, including metal melting, annealing, hardening, brazing, carbonizing, core baking, japanning and motor testing.

Many modern laundries generate steam by gas, and gas is being used more and more every year in small steam plants and for heating purposes. Gas water heaters and gas room heaters are becoming very popular and common in the homes, and in some cities gas-fired boilers are being used in home and apartment and office heating plants.

How Coal Is Wasted

Common practices of burning coal are wasteful and unscientific. Experts estimate that of each ton of coal mined in America at the present time, but 100 pounds of the fuel value of the coal is converted into mechanical energy. This means that whenever 2,000 pounds of coal are hoisted from the mine or hauled from the place it was stored by nature, 1,900 pounds, or 95 per cent, do no useful work and are practically wasted.

When the energy contained in coal is properly utilized, as in the manufacture of gas, increased heating values and useful by-products are obtained. In gas making, one ton of coal will produce approximately 1,400 pounds of smokeless fuel (coke), 12,000 cubic feet of gas, 25 pounds of ammonium sulphate, two to three gallons of benzol, and nine to twelve gallons of coal-tar.

Many millions of tons of coal are produced annually in the United States. Only ten per cent of this fuel goes into gas plants where by-products are obtained. If all of the products from these plants—gas, coke, ammonium sulphate, tar, benzol, etc.,—were sold, the price return from them would be fifteen times the retail price of the coal required to produce them.

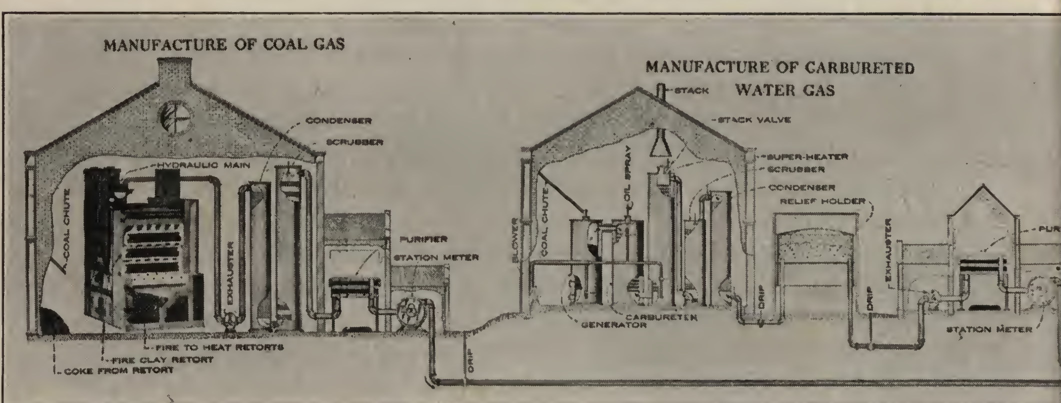
Steam railroads burn considerably more than one-quarter of all of the coal now mined in the United States. It takes seven pounds of coal, as burned in a modern steam locomotive, to produce the equivalent of one kilowatt of electric energy, which can be produced in a modern electric power house with but 2½ pounds of coal. The enormous saving in fuel which would result from the electrification of railroads in the United States is easily seen. If it were financially possible for railroads to substitute electric engines for steam locomotives they would save 64 per cent of their fuel bill, and, instead of consuming more than one-quarter of the coal mined in the United States every year, they would then consume less than one-tenth of the present coal output.

Cost of distributing coal adds to the needless expense of present-day practices of utilizing its energy. Coal shipments comprise about one-third of the tonnage of the railroads. They burn about one-twelfth of the coal for steam power, and haul the remainder to its destination. When known, scientific methods of burning coal are applied, this needless waste and expense will be curtailed, for both gas plants and electric generating plants will be built near to coal and water supplies.

Practical evidence of the modern, efficient method of burning coal is shown in the use of electricity for power at coal mines in central and southern Illinois. It has been found to be more economical to purchase electric energy than to use coal for power. In other words, even after freight charges are added to the cost of coal, power is cheaper when coal is converted into electric energy, than when coal is used for steam right at the mine, just as it comes from the earth.

When coal is used for the manufacture of gas, two useful fuels are obtained, gas and coke, and at the same time valuable by-products,

How Manufactured Gas



MODEL SHOWING HOW COAL IS TRANSMUTED INTO GAS AND DELIVERED TO T
WASHINGT

Two different gas manufacturing processes are pictured in the above model. One is the manufacture of gas by the distillation of bituminous coal in coking ovens which makes what is known as coal gas. The other makes gas through what is known as the carbureted water gas process. Coke and steam and usually an enriching material such as oil are used in making gas by this process. All gas companies do not use both processes. A description of both processes will be found in Chapter Five, beginning on Page 24.

Following is a brief description of some of the gas-making and distributing equipment pictured above:

Condenser

This is fitted with tubes surrounded by water and arranged so gas goes through the tubes and the water absorbs the heat in the passing gas.

Scrubber

This consists of a cylindrical tower containing a number of wooden trays having slats running crosswise in checker board fashion and where a water spray at the top of the tower keeps the slats wet and washes the impurities down over the wet surfaces.

Purifier

This is a large box containing two trays of oxide of iron where the sulphur impurities in the gas are absorbed by the iron and removed from the gas. The top or lid of the purifier can be raised, as shown by the dotted lines above, for changing the oxide. A pile of oxide undergoing airing is shown on the floor underneath the purifier.

Gas Holder

This is merely an open top circular tank filled with water in which a smaller open bottom tank is

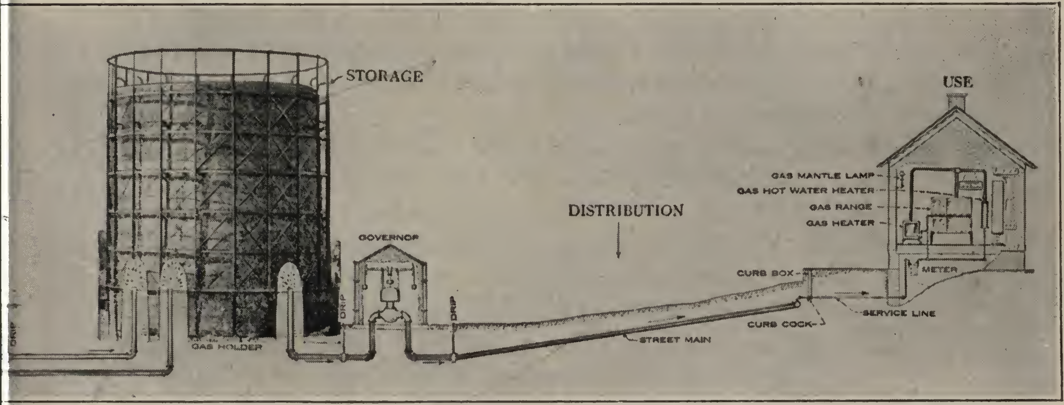
which would otherwise be wasted, are obtained.

All coal is not suitable to make gas, under present engineering development. Practically none of the kinds of coal used to produce electricity, can be used in gas-making.

The smoke-nuisance—the pollution of the air by smoke from antiquated coal burning devices—long has been a problem in our big cities and industrial centers, and has been a forceful argument for the conversion of coal into gas and electricity in modern plants.

Smoke injures health and destroys property. It is claimed that more persons are devitalized, disabled and poisoned by impurities contained in smoke-polluted air than by noxious ingredients in food or water. Density of atmospheric smoke increases pneumonia and causes other illnesses. As smoke diminishes the sunlight and increases the humidity during both cold and warm weather, it is certain that its presence exerts an important influence upon the health of all persons who live in a smoky city.

s Made and Distributed



IE HOME. ORIGINAL IN SMITHSONIAN INSTITUTION, U. S. NATIONAL MUSEUM, ON, D. C.

placed so that the gas can fill the space between the water and the top of the smaller inside tank called a "lift." When the gas volume is increased, the lift rises, when the gas decreases, the lift descends. The weight of the lift produces pressure on the gas.

Station Meter

This is merely a large meter which measures the volume of gas manufactured as it goes to the storage holder.

Storage

Gas is made at practically a uniform rate for 24 hours. The rate of use of the gas varies largely during different hours of the day. The function of the holder is to equalize the input and output.

Governor

As the gas comes into the holder and raises the telescoping sections, the weight of the metal that the gas must support increases and this increases the pressure on the gas, therefore, the higher the holder is raised the greater must be the resulting gas pressure.

To furnish a more uniform pressure to the consumer, the gas now goes through a governor which is merely a mechanical device where a variable intake pressure is changed to a practically uniform pressure in the distributing mains.

Delivery of Gas

From the governor the gas goes into the street mains, through the curb cock, service line, house meter and to the consumer's appliance.

Like the realization of an alchemist's dream, we have a serviceable transmutation of a baser substance into one of greater value in the unnoticed transmutation of crude, dirty, inert coal into energetic gas which can then be transmitted to a consumer far away where the turning of a gas cock makes it instantaneously available.

The Mellon Institute of Pittsburgh, which made an extensive investigation of the smoke evil and its cost, said in its report:

"In Pittsburgh we burn annually 16,000,000 tons of coal containing one-half of one per cent to 3 per cent sulphur. A large part of this sulphur escapes into the air where it exists for the most part as sulphuric and sulphurous acids. As a conservative estimate based on analyses which have been made here and elsewhere, we can say that at least 75 per cent of the sulphur in the coal escapes into the air. This, if considered as sulphuric acid would equal 500,000 tons, which if allowed to act on limestone would destroy 500,000 tons of limestone."

Statistics As To How Smoke Destroys Property

From the same bulletin is taken the following table of the comparative life of metal structural work in smoky and smokeless cities:

Metal	Smoky city Years	Smokeless city Years
Galvanized sheet iron	3 to 6	7 to 14
Galvanized sheet steel	3 to 4	5 to 10
Tin sheet iron	13 to 15	18 to 28
Tin sheet steel	6 to 10	10
Copper	10 to 20	No limit

The destructive effect of smoke-polluted air on the interior of buildings is more severe than on the exteriors. Wall papers, window curtains, carpets and upholstery are soiled and made rotten by the chemicals in smoke.

The economic cost of the smoke nuisance in London recently was estimated at $26,000,000 annually. This loss was divided as follows: Waste of fuel, $5,000,000; extra washing and wear and tear of linen, etc., $10,750,000; clothing, curtains, carpets and other textiles, damaged and renewed, $5,000,000; increased mortality, impairment of health, lessened working capacity, $1,600,000; all other loss and waste, $3,650,000.

Property Damage is Great

The Mellon Institute estimates the annual smoke loss and damage in Pittsburgh is $10,000,000, or almost as much as the city's yearly bill for domestic fuel. Since Chicago has nearly five times the population of Pittsburgh, it is probably conservative to put the annual cost of smoke damage in that city at $20,000,000, or nearly double that of Pittsburgh.

A survey shows that the laundry business in Pittsburgh amounts to $3.12 per capita per year. In Chicago it is $3.25; Cincinnati, $3.14, and St. Louis $3.06. In Philadelphia, where smokeless fuel is used, the average cost of laundry per person per year is $2.01. Chicagoans, therefore, pay $1.24 more for laundry than people who live in Philadelphia as a direct result of the smoky atmosphere. Soiled linen is a comparatively small item in each individual case, but the excess

cost to Chicago citizens is 50 per cent higher than the cost in Philadelphia, and if there are five or six people in the family, it is a real item of expense.

These figures do not take into account the bulk of the family washing, which in most instances is done at home and not sent to the laundries. Since there are approximately 3,000,000 people in Chicago the total extra cost to Chicago citizens for laundry is $3,720,000, exclusive of the cost of washing done at home.

Although the railroads are supposed to be responsible for a great deal of smoke, the commission which made an investigation of the problem for the Chicago Association of Commerce reported that steam locomotives were responsible for only 10 per cent of the smoke in Chicago.

This report stated that there were 300,000 buildings in Chicago discharging smoke into the atmosphere, compared with 1,600 locomotives. The total volume of air-diluted gases discharged from smoke stacks in Chicago each day amounts to approximately 47,000,000,000 cubic feet, or fifty-eight times as much as the average daily consumption of manufactured gas.

Smokeless Cities Possible

Experts estimate that smokeless cities are possible within twenty years. Manufactured gas will be the fuel of the future. From now on, coke will probably be used more generally. Coke is a smokeless fuel and it is being used more and more in connection with steam and hot water plants in private homes, apartment buildings, hotels and office buildings. As coke is produced in manufacturing coal gas, its use aids in fuel conservation.

Conservation of our natural resources, including coal, is one of the big problems of the age. Few people realize the enormous amounts of coal and oil burned every year. Back in the days of the Civil War approximately 33,000,000 tons of coal were produced annually and the consumption of petroleum, which was then just coming into use, was about two-thirds of a gallon per capita. Today, that would be less than one month's supply of coal and the use of petroleum has increased many thousand per cent.

Coal and oil supplies will not last forever and they must be used in such a way that we will derive the maximum efficiency from them. As has been pointed out, electrification of the railroads of the country would effect an enormous saving in the amount of coal burned each year. Use of gas and coke for heating also would effect big savings, in addition to making possible the reclamation of valuable by-products from coal, which now go up the chimney in smoke. When the day of electrification of railroads and gas-heated cities becomes possible there no longer will be any smoke nuisance and life in the cities will become more pleasant and healthful.

IV.—THE MANUFACTURE AND DISTRIBUTION OF GAS

How the gas companies today form one of the giant industries of the country and how they are operated and regulated.

IN the little more than one hundred years since the first gas company was organized in Baltimore the manufactured gas industry of the United States has grown until today it ranks among the leading industries of the country.

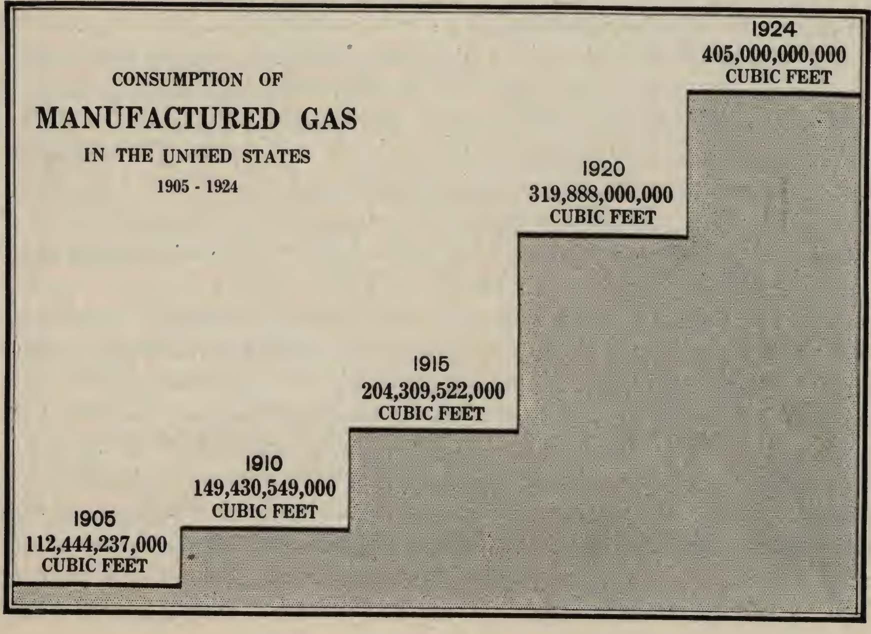
The companies comprising this great industry serve more than one-half of the population of the United States. They are practically all under private management.

Some of the companies serve only one town, while others serve a number of communities. Recently it has been found practicable in many cases to manufacture gas in large, efficient plants and pipe it to communities which are too small to have a plant for their exclusive use. In this way it has sometimes been possible to furnish gas service at reasonable rates to communities which otherwise would not have the conveniences of gas.

If all of the employes of these gas companies and their families lived in one place, they would constitute a city of more than 400,000 inhabitants.

How Gas Consumption Increases

The consumption of gas has increased steadily year after year, until now it is nearly four times what it was 20 years ago. In the



last 6 years alone the use of gas has shown an increase greater than in the previous hundred years of the industry's existence.

Engineers predict that the next decade will see an even more rapid growth. Not only is our country increasing in population but the people are finding more and more uses for gas. Industry has turned to gas for processes where heat is required, and every year many more homes are being heated with this fuel.

To make these billions of cubic feet of gas, the gas companies in 1924 used more than 8,000,000 tons of bituminous coal, about 2,000,000 tons of anthracite coal, 3,200,000 tons of coke and 980,000,000 gallons of oil.

How Gas is Used

More gas is consumed today for cooking, heating water, illumination and other domestic uses than for any other single purpose. In 1924, about 72.41 per cent of the gas sold was used in this way; 24.02 per cent was used for industrial purposes and 3.57 per cent for uses not classified.

While the big gas holders, the cylindrical shaped tanks which stand upright in big steel frames, are the most conspicuous feature of a gas plant, these holders are only the storage place for the gas as it is manufactured and awaiting use. There are buildings nearby where the gas is manufactured, and buried under the ground, throughout every city enjoying this service, are the mains which carry the gas to the consumers. There were 77,000 miles of these gas mains in the United States in 1924, not counting the hundreds of thousands of miles of pipes which lead from the bigger mains to the homes or factories of consumers.

Who Owns Gas Companies

Gas companies and other utilities, such as electric light, telephone and street railway companies, are not owned by those employed to manage them, but by thousands of thrifty investors who have bought securities with their savings. It is through sales of the securities that funds are provided for building the plants for the service of the people.

These companies are regulated by state commissions in practically all of the States of the Union. These commissions fix the rates and supervise the service of the gas companies and other utilities. In Illinois the regulatory body is known as the Illinois Commerce Commission, which is a part of the state government.

Under the system of regulation by the state, gas companies and other utilities are permitted to earn a fair return on their investment. If their earnings are considered excessive at any time their rates are adjusted. On the other hand, if their expenses increase, as during the recent war period, when wages and the cost of materials exceeded normal costs, commissions authorize increased rates, to permit the

earning of costs of production and a reasonable interest return on the money actually invested.

Neither gas companies nor any of the other public utilities are allowed to charge rates that are high enough to enable them to make further additions to their plants from profits. As the companies are permitted to earn only a fair return on the money invested, extensions and additions must be built with new money raised by the sale of additional securities. These securities cannot be sold until the regulatory commissions have investigated and are satisfied that the money is to be spent for needed improvements.

Why Monopoly is Necessary

Gas companies, as a rule, have a monopoly on the gas business in a community. In the old days competition was common, especially in some of the larger cities, but this proved unsatisfactory. When two or more utility companies do business in one community there is a duplication of plants, offices and employes. It is easy to understand that this means a double investment. One company can operate much more efficiently and economically than two or more smaller plants. This means lower rates and better service for the public.

As an example of how these companies have been forced to consolidate, all of Chicago is today served by The Peoples Gas Light and Coke Company, which is a consolidation of fifteen other companies. This company was incorporated under a special act of the state legislature, Feb. 12, 1855, and was the second oldest of the combined gas companies. It acquired all competing companies by authority of an act of the legislature passed in 1897.

New York City is supplied with gas by the Consolidated Gas Company of New York, which is a consolidation of seven companies.

How Manufacturing Processes Change

The method of making gas has changed as various uses have changed. Gas was originally made by the distillation of bituminous coal. This was the method of manufacture until about 1887, when competition became keen. In many cities there were several gas companies operating and electric lights were just beginning to come into use. As gas was used almost exclusively for lighting there was competition to see who could furnish the best light. Open flame burners of various patterns were used, incandescent mantles not being on the market at that time.

When the principal use of gas was lighting through open flame burners, a high candle power content in the gas was used. A good quality of coal will produce at best only 16 or 18 candle power gas. Gas engineers invented what is known as the "carbureted water gas process," in which steam and an enriching material, usually naphtha, crude oil or some form of hydro carbon, was used with coke. The

enriching material was used to increase the candle power lighting content of the gas. Not until the advent of the mantle burner was it possible to produce a large volume of light with a low content candle power gas.

Gas is now used, almost universally, for various heating purposes in homes and industries, and its candle power is no longer an important factor, especially since mantles have been adopted, generally, where gas is used for illumination. Consumers are now interested in the calorific quality of gas alone. By this is meant the number of British thermal units (commonly called B.t.u.'s) which the gas contains. B.t.u.'s are the units of heat measurement, just as pounds and inches apply to other measurements.

The statutes of many states and the ordinances of many cities formerly required that gas should have a 22 candle power content and as a resultant of this candle power requirement there was in each cubic foot of gas, approximately 650 B.t.u.

As oil became more expensive it was found that a very satisfactory gas for lighting purposes with the mantle burner, was a gas distilled from coal, which ran about 16 candle power and 550 B.t.u. without enrichment. In order to enable gas companies to manufacture and distribute this gas without enrichment, the calorific value of the gas was reduced as well as the candle power content.

Gas Now Principally Used for Heat

The practice of requiring a high candle power content is now almost obsolete as it is realized that gas is now used more for heating purposes, than for lighting. As more than 80 per cent of the gas sold today is used to produce heat, its heating qualities are more essential than candle power content. Heat produced by gas is used for many different purposes. While gas is used to some extent to heat rooms, houses and even office and apartment buildings, heat produced by gas is used widely for cooking, for heating water and in hundreds of different manufacturing processes where economical, clean heat is essential.

Even for lighting today, candle power does not matter, as practically all gas lighting is done with incandescent mantles. It is the heating of the mantle to incandescence that makes the light; not the actual "light" of the burning gas. A high candle power gas is in reality a detriment to good lighting, where a mantle is used, because of this. Gas with a high candle power content smokes the mantle and therefore a heat unit gas produces a better light wherever mantles are used.

It is now quite generally recognized that every piece of useful work to which gas can be applied, can be as successfully accomplished with a gas content of 325 B.t.u. as with a gas containing a higher calorific value. Inasmuch as the candle power requirement is not

longer necessary, the tendency of regulatory authorities is to withdraw specified calorific standards and to permit gas companies to manufacture gas of such calorific content as they can make at the lowest cost with the materials procurable and with the lowest capital investment. This results in the lowest possible price to the consumer.

In practically all states regulatory commissions have recognized this fact. Candle power requirements have been removed in most instances and gas is being sold on a heat unit basis. A heat unit, or B.t.u. as it is commonly called—meaning British Thermal Unit—is the amount of heat required to raise one pound of water one degree Fahrenheit in temperature.

An instance of this is the general order passed by the Colorado commission, which provides that a company shall have the right to make a gas of any calorific content that it may be able to manufacture economically. The only requirements are that the gas be of adequate heating quality for the uses to which it is to be put and that the company file with the commission a statement of the character of the gas which it proposes to make and submit data to the commission from time to time, to show that the specifications are being lived up to. The practice of permitting the sale of gas of unrestricted calorific value enables gas companies to sell gas at the lowest possible price, thus opening the way for the universal application of gas for fuel purposes for the benefit of all.

V.—HOW GAS IS MADE

A description of the methods of manufacturing gas.

COAL gas and so-called carbureted water gas are the two most common kinds of manufactured gas. One is called coal gas because it is made by distillation of coal and the other is known as carbureted water gas because it is made by shooting steam through burning coke, and oil is added to enrich it.

Gas engineers have been making extensive experiments recently in the use of bituminous coal instead of coke in the manufacture of gas by the carbureted water process. These experiments, it is believed, will result in the more economical production of gas and will, at the same time, enable gas companies to utilize certain grades of coal heretofore not usable in the manufacture of gas.

The series of operations connected with the preparation and distribution of coal gas embrace the process of distillation of the coal, condensation, scrubbing or washing, purification, measuring, storing and distribution to the mains from which the consumer's supply is drawn. As different kinds of coal vary greatly in their chemical constitution, there is a wide difference in their value and applicability for the manufacture of gas.

Of the leading varieties of coal—anthracite, bituminous and lignite—it is found that bituminous alone yields varieties really serviceable for gas making. Different kinds of bituminous coal also vary largely in gas making value. As a rule, the coal that yields the largest percentage of gas also produces the richest quality. Anthracite may be regarded as a sort of natural coke from which the volatile constituents have already been driven off, and lignite is rarely used, owing to its large proportion of oxygen and the amount of water in its constitution.

An Interesting Experiment

If you fill the bowl of an ordinary clay pipe with small fragments of bituminous coal, paste clay over the top, and place the bowl in a bright fire, you will see that smoke immediately begins to issue from the stem of the pipe projecting beyond the fire. The smoke soon ceases, and if a light is applied then, the issuing gas burns with a bright steady flame, while a black, thin, tarry liquid also oozes out of the stem. After the combustion ceases there is left in the bowl a quantity of "char" or coke.

This simple experiment is, on a small scale, an exact counterpart of the process by which the distillation of coal is accomplished in the manufacture of coal gas. The thin, tarry liquid referred to, contains all of the wonderful by-products.

How Coal Gas Is Made

In manufacturing coal gas, coal is heated in big retorts. Iron, clay and brick have all be used in the construction of these gas retorts. Retorts are kept at a bright red heat. For coal with a higher percentage of volatile matter, a higher temperature is needed than for coal less rich in gas. Care must be exercised so that the quality of the gas is not impaired by sulphur compounds which would be given off if the coke were over-burned.

Upon leaving the retort the gas is about the color of smoke and, of course, at a higher temperature. It is necessary to reduce the temperature, which also reduces its bulk, and to remove whatever impurities it is carrying along with it. The first process of condensation is performed by having the gas pass through a series of water-cooled pipes, which rise from a trough partly filled with water. In this process, the gas is not only considerably reduced in temperature but the tar and ammoniacal liquor condense and drop to the bottom of the pipes. Here they encounter the water, the tar subsiding to the bottom and the ammoniacal liquor floating on top.

After leaving the condenser the gas has several other obstacles to encounter before it goes into the mains. It is obvious that its progress would be impeded and a "back pressure" on the retorts created, by the obstacles it has to pass, if it were not helped on its way. For this reason, engines called "exhausters" are installed, which draw the gas from the condensers and "boost" it on its way to the storage tank

The gas next passes through a scrubber which removes from it all that remains of ammonia, sulphureted hydrogen, and other gas impurities. The agencies adopted are partly mechanical and partly chemical. The gas is first passed through a scrubber, which is ordinarily in the form of a high tower or a hollow column. It may be filled with scrap tin or some coarse shavings, laid on boards arranged in tiers. The gas works its way through these obstructions, leaving tar and other impurities on the sharp edges it encounters. It then passes on to the purifiers.

How Impurities Are Removed

Purifiers are flat iron boxes. They are generally arranged in sets of four; three being in use, through which the gas passes in succession while the fourth is being renewed. The boxes are filled with shavings which have been soaked in a solution of oxide of iron. The oxide serves the purpose of decomposing sulphureted hydrogen, the portion of the sulphur forming a sulphide with the iron. When a sufficient quantity of gas has been passed through, the box is opened and the mixture is removed and exposed to the air, under which condition it combines with the oxygen and again becomes fitted for use as a purifier.

The gas is now ready for use and is passed on through the plant meter and stored in the gas holders. The gas holders are huge cylindrical-shaped tanks and are the most noticeable feature of a gas plant.

So-called carbureted water gas, which is used at present in about 75 per cent of the cities of the United States, is the invention of Thaddeus S. C. Lowe, an aeronaut, who died in 1913. Lowe became interested in aerostatics and just before the Civil War made a balloon trip of seven hundred miles. During the Civil War he was made chief of the aeronautical corps in active field operations and from captive balloons watched and, by telegraph, reported the movements of the Southern troops. Lowe experimented in gas making in connection with his balloon experiences, and in 1874 built a water gas plant at Phoenixville, Pa., for the manufacture of illuminating gas made from vaporized water, or steam, carbureted by oil.

How Carbureted Water Gas Is Made

The term "water gas" is wrong, but was used by gas engineers in the early days of its development to distinguish it from coal gas, which was then in general use. Engineers called the new gas "water gas" because steam had to be used in the process. Although steam was necessary in the process, the gas was in reality made from coke and oil.

Carbureted water gas is manufactured in three round steel towers, the generator, the carbureter and the superheater.

About three-fourths of the gas is generated or manufactured in the generator which is lined with fire brick. The generator is con-

nected with a similarly shaped tower—the carbureter. This part, also, is lined with fire brick, and is almost filled with layers of bricks placed criss-cross, thus forming a sort of honeycomb arrangement. The carbureter serves the same purpose in a gas plant as it does in an automobile, that is to gasify a liquid. But, in the gas works, gas-oil is used, while in an automobile gasoline is used. The carbureter is connected to a third steel tower also honey-combed with brick. This is the superheater and is used to complete the work of the carbureter.

The Part Steam Plays

The process of manufacture is as follows:

The generator is filled with a good quality of coke which is ignited. Air is blown through the apparatus for from two to four minutes until the coke is white hot. The hot gas from the burning coke in the generator passes into and through the honeycombs of the carbureter and superheater so that the bricks in those chambers are heated to a dull cherry color.

At this time the air is shut off, and steam is sent into the generator. As the steam passes through the hot coke, it reacts chemically with the coke, producing two gases, carbon monoxide and hydrogen, which pass into the top of the carbureter.

Because this gas mixture has a low heating value, it must be "enriched" by mixing with it a gas of high heating value derived from gasified oil. To do this, gas oil is sprayed into the top of the carbureter. As this oil passes through the honeycomb of hot bricks in the carbureter and superheater, it is broken up into gases which have a high heating value. The gases from the oil and coke mix and are now ready to be purified.

The hot crude carbureted water gas passes from the superheater through water in the wash box where some of the tar is removed and the gas cooled. From the wash box, the gas passes through the hot scrubber, coming into intimate contact with hot water which removes most of the tar without removing the "enriching" vapors. Gas leaving the hot scrubber contains much water vapor which must be removed by cooling the gas in the condenser. From the condenser, the gas passes to the relief holder, which is a tank holding from a few thousand to several hundred thousand cubic feet of gas, depending upon the size of the plant. It serves to equalize the flow of gas through the various purifying apparatuses.

From the relief holder, a pump, the exhauster, forces the impure gas through the shavings scrubbers—towers which are filled with wood shavings. The remaining droplets of tar stick to the shavings.

It is the practice in some plants to take advantage as much as possible of the condensing facilities of the relief holder and do away

with the hot scrubber. By this method the gas passes from the wash box to the relief holder and from the relief holder it passes through the condensers and then through the exhauster to the shavings scrubber.

All Impurities Removed

But, the gas still contains hydrogen sulphide, a gas which has a bad smell and, unless removed, might ruin the gas range and the finish of the woodwork in the home.

To remove hydrogen sulphide, the gas is forced through purifiers, which are very large steel boxes equipped with wooden trays upon which a mixture of wood shavings and oxide of iron is placed. The shavings keep the iron oxide porous so that the gas will be brought into intimate contact with the oxide. As the gas passes through the oxide, the hydrogen sulphide in the gas unites chemically with the oxide and produces iron sulphide, a solid which remains in the purifying box, while the gas passes on.

The gas is now at last pure and ready for use. It is passed through a plant meter, which measures the quantity of gas made, and is then stored in a gas holder, from which it is pumped into large gas mains and distributed to customers. These mains and smaller pipes, leading to the homes and factories of consumers, form a vast net-work of arteries and veins which spread throughout the entire city, delivering gas to the customers when needed.

VI.—THE BY-PRODUCTS OF GAS

A brief sketch of the valuable products which are derived from the manufacture of gas.

IN the manufacture of gas, there are derived valuable by-products from which are made many commodities that are used daily by everyone. It may be rather difficult to associate the odor of gas with delicate perfumes yet many perfumes are produced from coal tar, which is one of the by-products of a coal gas plant. Dainty dyes, saccharin, valuable oils, ammonia and many drugs and chemicals are made from these by-products.

Thus it will be seen that the common method of burning of coal destroys many valuable by-products which are saved when coal is used for making gas.

As only about 16 per cent of the soft coal mined in the United States is "coked" or used in the manufacture of gas and the remainder is used for other purposes, it is easy to understand that consumption of coal by unscientific methods is a wasteful, extravagant custom, not only producing smoke but destroying valuable contents.

If coal is burned in the open air or in a stove or furnace, nothing is left but ashes.. In making coal gas, coal is heated in a closed retort, where the oxygen of the air cannot reach it. After the gas has been

driven off, carbon or coke remains. Coke is used in making carbureted water gas and for many other purposes.

Tar, ammonia, sulphur and other products are removed from the gas in purifying processes after it escapes from the retort in which the coal is heated. In the early days of gas manufacture there was no use for this smelly mass removed from the gas. This black, ill-smelling mass today is one of the most useful materials in the world. Chemists have found thousands of ways to use the by-products derived from it, and use of these products cover a wide field, from the battlefield to the society ball room.

Some of The By-Products

By-products of coal gas plants are used in making many articles, among them the following:

Drugs such as aspirin, phenacetin, antipyrene, acri-flavine, sulphonal, sal volatile, salvarsan, carbolic acid, lysol.

Fertilizers such as sulphate of ammonia to supply plants with nitrogen and gas lime (blue billy) used to kill worms at plant roots.

Tar—dehydrated tar used for waterproofing surfaces, macadam roads, etc. Creosote for treating railroad ties and street paving blocks. Carbon bisulphide for dissolving rubber.

Ammonia—Used daily in thousands of different ways in households and in industry. Used for manufacturing ice, scouring wool for clothing, recovering the grease which is used for cosmetics, etc.

Colors—All dyes, including indigo.

Moth balls—Hydro-carbon formed into white balls made from pure napthalene.

Chemicals used in photography such as pyrogallic acid developer, sulpho-cyanide and hydro-quinone.

Carbons for electric arcs used in search lights and carbon brushes for dynamos.

Explosives such as T. N. T.—Tri-nitro-toluol (toluol nitrated three times) famous explosive used in shells, hand grenades, bombs, etc. Lyddite (picric acid) violent explosive.

Perfumes—most delicate essences produced from derivatives of tar.

Coke used in blast furnaces, foundry cupolas, in the manufacture of carbide and for manufacturing carbureted water gas. Coke also replaces anthracite in domestic furnaces and stoves.

Saccharin—A substance which has a sweetening power more than five hundred times that of sugar.

Thus, it will be seen that gas not only makes an efficient and economical fuel, and eliminates the smoke nuisance, but also furnishes colors that eclipse the rainbow in hue, and many other products of use to mankind.

VII.—THE GAS METER

The story of its invention and how it operates.

THE gas used by every customer is measured where it is used either in the home or factory. The little black box in the basement, or some other unobtrusive place, known as the gas meter measures the gas as it is used in the kitchen range, the water heater or in any other gas-burning appliance.

The gas meter is one of the most simple and accurate measuring devices ever invented. Everyone is familiar with the outside of a gas meter, but only a few know how simple, yet accurate and positive, is the mechanism on the inside.

The meter was invented by William Richards in 1844. So simple is the meter in principle and constructon that no substantial improvement in it has been possible since that date. Hundreds of inventors have tried to perfect a better gas measuring device, but without success, and while there have been improvements the meter of today works on the same principle as did the first meters nearly eighty years ago.

Works Like Human Lungs

A meter, that is properly located and protected from extreme heat and cold will measure gas accurately, day and night from 5 to 12 years, without requiring attention. In spite of this evidence of reliability most gas meters are examined periodically. The Illinois Commerce Commission, which regulates the gas companies and other utilities of this state, requires that gas meters be removed from the customers' premises and tested for accuracy every seventh year in service.

If you should take off the top and sides of a meter you would find it divided into two parts. The upper part contains the registering mechanism, while the lower part contains two diaphragms or bellows. To understand how a meter operates, think of the bellows as human lungs. The bellows are of leather and they inhale and exhale gas just as the human lungs take in and send out air, except that the bellows work one after the other; that is, when one is inhaling gas from the mains the other is exhaling gas into your house pipes.

These bellows do not operate unless gas is being used. When a valve is opened on a gas stove and the gas lighted, the gas begins to force its way through the meter. The gas cannot go through the meter unless there is an outlet so the meter is not operating and measuring gas except when gas is being used.

How the Meter Operates

The meter is similar in principle to any slide valve steam engine. The gas enters the meter and passes through to the valve enclosure

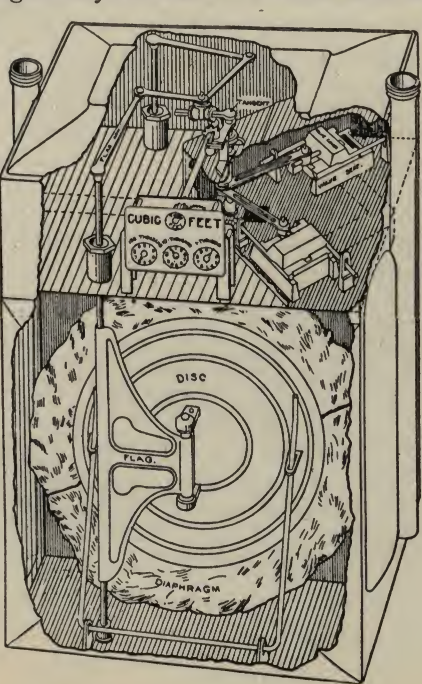
through an opening in the horizontal partition. From this point it enters either one of the two diaphragms or bellows. Should the port leading into one diaphragm be just opening the gas will enter this one and in doing so it assists in the further operation of continued movement of the valves.

The action of filling and opening one of the diaphragms expels a part of the gas surrounding the outside of the diaphragm and already contained in this compartment. The expelled gas, leaving through the compartment port, is directed by the position of the "D" shaped slide valve through the center, or outlet, port and thence into the outlet pipe. This movement of the diaphragm, communicated through the connecting links, rotates the valve crank and changes the relative position of the valve covers.

Gas flowing into the valve enclosure now enters through the compartment port, exerts its pressure on the opposite side of the diaphragm, reversing its movement and expelling the gas contained within the diaphragm through the same port which it before entered, the gas then passing through the central valve port and on into the outlet port as in the first instance.

Similar to Steam Engine Piston

The action of filling one diaphragm may be said to be included in one phase of a cycle, the emptying a second phase and as the operation of the second diaphragm, on the opposite side of the partition is exactly the same, we have four phases to one cycle or complete operation of the meter during which the valve crank makes one revolution.



If you were to attach to an ordinary steam engine a counter that would record the number of times its piston moved back and forth, you could, by knowing the displacement of the piston, tell the volume of steam used. To obtain similar information as to the amount of gas used, a gas meter is furnished with a recorder or index equivalent to a steam engine counter, which by suitable con-

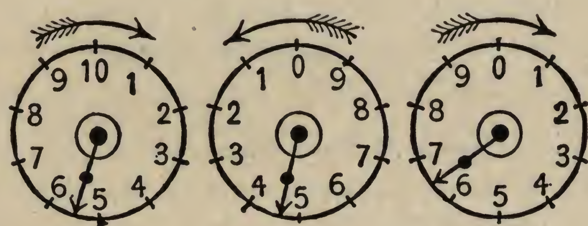
necting gearing is made to record, in cubic feet, the number of times the two diaphragms have been made to travel in and out, as explained.

It is apparent that it is impossible for a meter to work automatically unless gas is passing through it—as it is for a steam engine to operate without steam. The valve which starts the meter is the burner key on a gas range or other gas appliance. The gas companies have no direct control over how much gas passes through any particular meter, this being entirely up to the customer. The company makes the gas and lays the pipes that bring this fuel to the curb outside the home or factory. The customer is the engineer who determines how much gas shall be used by opening a gas burner and starting the little engine—the gas meter.

How to Read Your Meter

You can read a gas meter as easily as you can tell the time by looking at a watch.

Supposing the hands of the dials are pointed like this:



You must then do two things:

First—reading from left to right, put down the lowest of the two figures next to the hand on each dial. On the dials shown above, these are 546.

Second—Add two ciphers to the figures taken from the dial—(which makes in this case, 54,600) and from the figures thus obtained, subtract the meter reading of the previous month as shown on your last gas bill. The result will be the cubic feet of gas used during the month.